Chapter 4
Treatment Factors for Phosphorus BMPs

Best Management Practices (BMPs) must be designed to meet the required phosphorus reductions based on the Project Phosphorus Budget (PPB). The lowest maintenance BMP that meets the PPB should be selected.

This chapter presents the treatment factors that the Department recommends using for the design of a variety of phosphorus control BMPs.

4.1 Rules of Thumb for BMP Design and Selection

Before presenting the recommended treatment factors for actual BMPs, there are several rules of thumb about selecting a BMP that should be considered.

1. **Given a choice, select the lowest maintenance BMP that will provide the required phosphorus removal.** For example, natural wooded buffers require much less long term inspection and maintenance than most other BMPs, so, if space and topography allow, buffers are the preferred BMP.

2. **The buffer and source area (i.e. lawn, parking lot, etc.) should be laid out for runoff to pass in non-channelized sheet flow from the source area and be evenly distributed across the face of the buffer.** If this design is not possible, runoff may first be concentrated and then redistributed into the buffer using a level spreader or ditch turnout, but care must be taken not to hydrologically overload the buffer and to maintain the level spreader (see design standards for level lip spreaders in Volume III, Chapter 8).

Natural wooded buffers are preferred over other BMPs due to their low maintenance.

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4.2 Common BMPs and their Standard Sizing

Volume III of this manual, BMP Technical Design Manual, presents the standard designs for the most commonly used BMPs including buffers, wet detention basins and filtration and infiltration systems. These standard BMP designs are sized to provide retention of approximately 60% of the annual stormwater phosphorus export, and thus would have a treatment factor of 0.40. The standard sizing of these BMPs is as follows:

- Wetponds. Standard sizing (BMP_{ST}) for wet ponds requires a storage volume below the permanent pool elevation of at least 1.5 inch of runoff times the subcatchment's impervious area plus 0.6 inch of runoff times the subcatchment's non-impervious developed area. The pond must have a mean depth of at least three feet, and a length to width ratio of 2:1 or greater. See Chapter 4 of Volume III.

- Underdrained vegetated soil filter or other approved filter. Standard sizing (BMP_{ST}) for filters requires storage of a runoff volume equal to 1.0 inch times the subcatchment's impervious area plus 0.4 inch times the subcatchment's non-impervious developed area for discharge solely through an underdrained vegetated soil filter having a single outlet with a diameter no greater than eight inches, or though a proprietary filter system approved by the department. See Chapter 7 of Volume III.

- Infiltration Systems. Standard sizing (BMP_{ST}) for infiltration systems requires storage of a runoff volume equal to 1.0 inch times the subcatchment's impervious area plus 0.4 inch times the subcatchment's non-impervious developed area for infiltration into the ground. Pre-treatment of stormwater must occur prior to discharge to the infiltration area. See Chapter 6 of Volume III.

- Vegetated Buffers. Standard sizing (BMP_{ST}) of flow path lengths for buffers depends on the type of buffer, the soil type and slope of the buffer, and the nature and extent of land use in the contributing watershed for phosphorus export reduction. Standard sizing for a given buffer type in a given landscape and development setting can be determined using the tables found in the Buffer Chapter, Chapter 5, of Volume III. There are four types of buffers:
  - Buffers with stone bermed level lip spreader;
  - Buffers adjacent to the down hill side of a road;
  - Ditch turn-out buffers; and
  - Buffers adjacent to residential, largely pervious or small impervious areas.

4.3 Determining BMP Phosphorus Treatment Factors

In designing the stormwater management system, the treatment factor of the selected BMPs for the project can be adjusted based on their sizing. A BMP's treatment factor may be reduced or enhanced by modifying either the volume of stormwater runoff it will store and treat or the length of flow path through a buffer. The two formulas presented below provide (1) a way of adjusting the standard sizing of BMPs described in Volume III and in Section 4.2 of this volume to provide a desired treatment factor, or (2) a way of determining the treatment factor of a given size BMP.

Wetponds, underdrained soil filters, infiltration systems and vegetated buffers may be sized to provide more or less treatment than if sized as provided in Volume III by adjusting, up or down, the volume of runoff stored and treated, or, in the case of buffers, the flow path length. There is, however, a point at which further increase in sizing of a BMP is not likely to significantly improve the BMP's ability to retain phosphorus. This limit is expressed as a minimum treatment factor for each type of BMP. Treatment factors may not be adjusted below this minimum. Minimum treatment factors are discussed later in this chapter and are presented in Table 4.1.

(1) If you know the treatment factor that is needed and can adjust your BMP design to meet it, use the following equation to determine either the volume of runoff that must be stored and treated or the necessary buffer flow path length to provide a required treatment factor:

$$\mathbf{BMP_{TF} = 0.4*(BMP_{ST}/TF)}$$

Where:

TF = Desired treatment factor (1-Removal Efficiency of the BMP)

BMP_{ST} = Standard sizing for the BMP, as described in Section 4.2

BMP_{TF} = Required sizing to achieve the desired treatment factor

BMP sizing is based on either volume of runoff stored and treated or buffer flow path length.

Example 6: Alternative BMP Sizing

Problem:

5.0 pounds/year of phosphorus is created from the runoff of a four acre parking lot. The owner wishes to design a wetpond to achieve a desired maximum phosphorus export from the parking lot of 1.8 pounds/year to meet the project's phosphorus budget for that area. What size pond will be needed to achieve this export?

Solution:

The desired treatment factor is calculated as:

TF = Desired Export/Existing Export = 1.8/5.0 = 0.36 or

Using the Volume III sizing criteria, 60% removal efficiency can be achieved with a wet pond, or a 0.4 TF. This requires a permanent pool volume of 1.5 inch of runoff over the impervious area. Since this project requires a 36% TF, the designed pond's permanent volume for this project will need to be relatively sized to the 1.5 inch of runoff over the impervious area. Thus, the permanent pool of the pond can be sized as follows:

$BMP_{TF} = 0.4*(BMP_{ST}/TF)$

$= 0.4*(1.5/0.36)$

$= 1.57$ inch of runoff for the impervious area

The permanent pool of the pond must be sized for 1.57 inches of runoff over the impervious area. If the pond is discharging to a stream before reaching the lake, then the channel protection volume needs to be provided per Volume III.

(2) If, on the other hand, you know the size of a given BMP, and need to determine its treatment factor, use the following formula:

$$\mathbf{TF = 0.4\ BMP_{ST} / BMP_{TF}}$$

Where:
TF = Treatment Factor (1-Removal Efficiency of the BMP) of the BMP
BMP_{ST} = Standard sizing for the BMP as described in Section 4.2
BMP_{TF} = Actual sizing of the given BMP

BMP sizing is based on either volume of runoff stored and treated or buffer flow path length.

4.4 Minimum Treatment Factors

There is a limit to the amount of phosphorus removal a BMP can accomplish, no matter how large one makes it. The physical, chemical and biological processes that a BMP relies on to remove pollutants have limitations and making a BMP larger generally does not change the limits on the effectiveness of these processes; it only means that all, rather than just part, of the runoff from larger, infrequent storms will get treated by the BMP. However, a limit has been placed on the amount which various BMPs may be enlarged to increase their removal efficiency and reduce their treatment factor. Table 4.1 presents the minimum treatment factors that are allowed for selected BMPs. BMPs may be enlarged from their standard sizing criteria as outlined in Volume III to reduce their treatment factors to a point, but treatment factors may not be reduced below the minimums in Table 4.1.

Table 4.1
Minimum Treatment Factors for Selected BMPs

	Treatment Factor (1-RE)	
Wetponds		
• Single Pond	0.3	
• Two ponds in series (designed per Volume III, Chapter 4)	0.25	
• Three ponds in series (designed per Volume III, Chapter 4)	0.2	
Underdrained Soil Filters and Other Approved Filters		
• On sand, loamy sand or sandy loam with 2 ft between bottom of system and restrictive layer	0.15	
• All other filters	0.25	
Infiltration		
• All infiltration BMPs	0.1	
Vegetated Buffers (maximum flow path length = 150'*)	**Meadow**	
Buffer Hydrologic Soil Group (and Texture)	**Forest**	**Meadow**
• A or B	.15	0.2
• C (sandy loam or loamy sand)	0.2	0.3
• C (silt loam, clay loam or silty clay loam)	0.3	0.4
• D (non wetland)	0.4	NA

*The maximum allowed flow path length in a buffer is 150 feet unless the runoff is redistributed by a midcourse stone bermed level lip spreader.

Example 7: Alternative Treatment Factor and Minimum Treatment Factor

Problem:
The available downgradient meadow buffer for a one acre parking lot has 150 feet of sheet flow on a 6% slope and on HSG C soil (sandy loam). What would be the allowable treatment factor for this buffer?

Solution:
According to Table 5.1 from Volume III, the required forested buffer length on sandy loam C soils to adequately treat stormwater runoff is 100 feet. Thus, the Treatment Factor for the available buffer on this project is:

$$\begin{aligned} TF &= 0.4\ BMP_{ST}/BMP_{TF} \\ &= 0.4\ (100/150) \\ &= 0.27 \end{aligned}$$

However, according to Table 4.1, the minimum treatment factor that may be used for a forested buffer on C sandy loam soil is 0.3. Therefore, the treatment factor is limited to 0.3.

Example 8: Maximum Treatment

Problem:
Using the minimum treatment factors in Table 4.1, calculate the maximum amount of runoff that can be treated using an underdrained filter that has less than 2 feet of separation between the bottom of the system and the restrictive layer and that is treating runoff from an impervious area.

Solution:
For this situation, the minimum treatment factor from Table 4.1 is 0.25. Standard BMP sizing calls for treatment of 1.0 inch of runoff over the impervious surface. The maximum runoff that can be treated in such a filter is calculated as follows:

$$\begin{aligned} BMP_{TF} &= 0.4*(BMP_{ST}/TF) \\ &= 0.4*(1.0/0.25) \\ &= 1.6 \text{ inch of runoff} \end{aligned}$$

The filter bed can only be expanded by area and not depth.

4.5 Multiple BMPs Placed in Series

If multiple BMPs are being used in series, make sure that the last BMP in the series has the ability to remove the types of pollutants which are likely to reach it. For example, treatment credit should not be taken for a filter located downstream of an efficient forested buffer. The filter will not add significant additional treatment because the buffer will most likely have already removed all the fractions of stormwater phosphorus that the filter could.

If multiple BMPs are being used appropriately in series, the net treatment factor for the series of BMPs is the product of the lowest (most efficient) treatment factor of the individual BMPs in the series and the square root of the treatment factor(s) of the less effective BMP(s). For example, if a small wetpond with a treatment factor of 0.6 drained to an engineered infiltration area with a treatment factor of 0.4, the net treatment factor for the two BMPs would be 0.4 x 0.6 = 0.31.